
Table of Contents

Electronic Signals

Subject	Page
Electronic Signals	3
Purpose of Electronic Signals	3
AC Voltage Signals	4
Inductive Signals (Induced Voltage)	4
DC Voltage Signals	5
DC Analog Signals	5
DC Analog Sensors	5
NTC Sensors	5
PTC Sensor	6
Potentiometers	7
DC Digital Voltage Signals	8
Switched B+ (High/Low) Signal	8
Switched B- (High/Low) Signal	9
Modulated Square Wave	10
Frequency	10
Pulse Width	11
Duty Cycle	11
DC Digital Sensors	12
Hall Effect Sensors	12
Magnetoresistive Sensors	13
Designated Value Signals	15
Coded Ground Signals	16
DC Digital Input/Output Stages	17
Transistor Final Stage Function	17
Modulated, Momentary, Constant B- as Input/Output	18
Momentary/Constant B+ as an Input/Output Signal	18
Constant B-/B+ To Energize a Component	19
Modulated B-/B+ To Operate A Component	20

Electronic Signals

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Explain the operation of an Inductive Sensor.
- Understand the difference between analog and digital signals.
- Know the difference between NTC and PTC type sensors.
- Explain the operation and use of different types of signals
- Recognize signal types on the oscilloscope.

Electronic Signals

Purpose of Electronic Signals

Electronic signals move information much like cars move passengers down the highway. It would be difficult to get to work without transportation, and there would be no transportation without signals.

Signals allow devices (e.g. sensors or switches) to communicate with control modules (either complicated processors or simple relays) which in turn perform or request (through more signaling) other functions to be carried out.

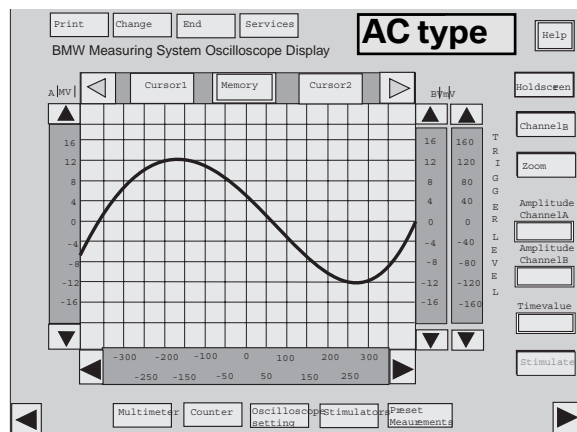
Signals inform the Climate Control of the outside air temp or tell the brake lights the right time to illuminate.

The use of electronic signals goes far beyond the basic application of electron flow to control components, enabling complex information to be passed from one component to another.

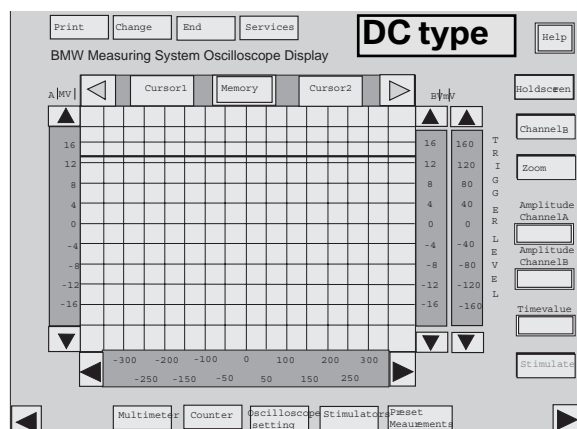
The data (input or output) is conveyed through various forms of changing voltages, resistances, current or frequency modulation.

Signals are divided into TWO main groups:

- AC type signals



- DC type signals



AC Voltage Signals

Inductive Signals (Induced Voltage)

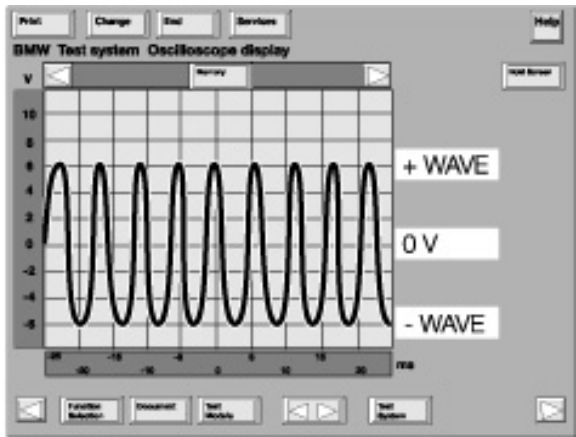
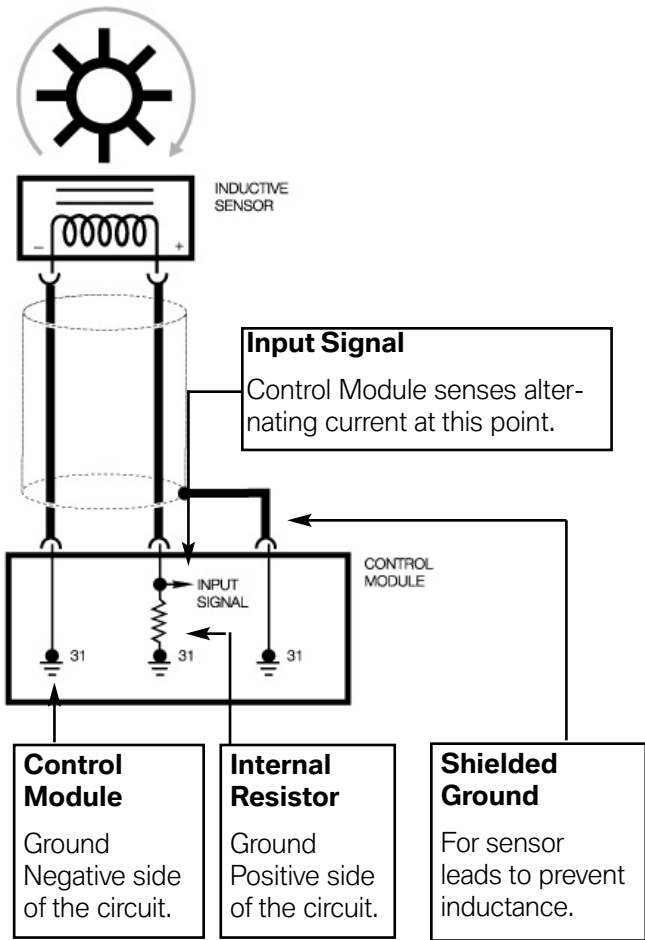
Inductive sensors produce an AC Sine Wave signal. The AC voltage is induced by the shifting of a magnetic field. The sensor consists of an impulse wheel (the moving part) and a coil wound magnetic core (the stationary part).

As each tooth of the impulse wheel approaches the sensor tip, the magnetic field of the sensor shifts toward the impulse wheel and induces a voltage pulse in the windings.

As the teeth move away from the sensor, the magnetic field shifts back inducing a voltage pulse in the opposite direction.

This shifting of the magnetic field produces an alternating current (positive to negative).

Control modules which receive this alternating current, count the impulses (shifts from positive to negative) and interpret the speed of rotation of the impulse wheel.



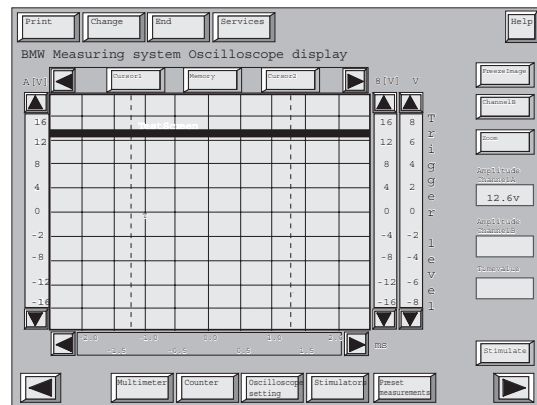
Note: Voltage levels are dependent on sensor design. Not all inductive sensors produce 12 volts.

DC Voltage Signals

Five Types of DC Voltage Signals Are Used:

- Analog Signals
- Digital Signals
- Designated Value Signals
- Coded Ground Signals
- Transistor Signals

DC voltage signals are based on either 5 volts or 12 volts.



DC Analog Signals

Analog signals transmit information through an electrical circuit by regulating or changing the current or voltage.

The voltage of the signal has no fixed value. The value may be anywhere in the operating range of the signal.

Three sources of analog signals are:

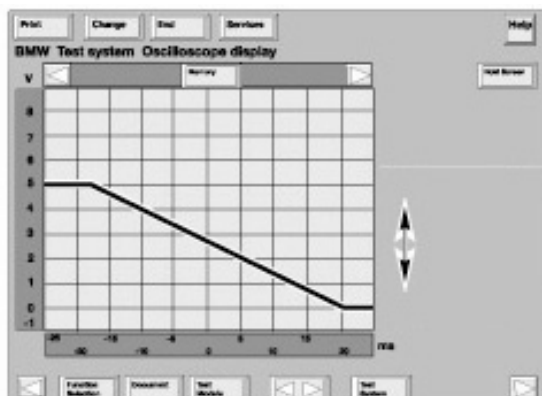
- NTC Sensors
- PTC Sensors
- Potentiometers

DC Analog Sensors

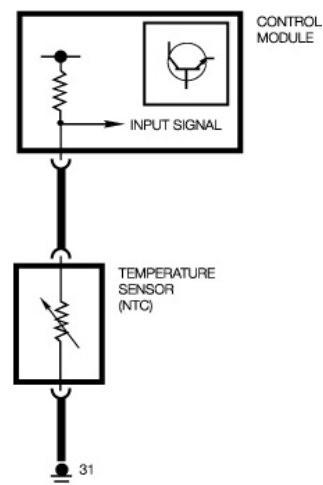
NTC Sensors

NTC (Negative Temperature Coefficient) sensors change resistance based on temperature.

As the temperature goes up the resistance goes down. This decrease in resistance causes the voltage drop across the sensor to decrease and the input signal voltage at the control module decreases.



Typical NTC Sensor Signal



PTC Sensor

PTC (Positive Temperature Coefficient) sensors also change resistance based on temperature. In a PTC sensor as the temperature goes up the resistance also goes up. The increase in resistance causes the voltage drop across the sensor to increase and the input voltage signal at the control module increases.

When troubleshooting a faulty input display, the input signal must be verified as “good” BEFORE the control module is replaced.

When checking a NTC Sensor look for these voltages and problems:

- 0v = no supply voltage or shorted to ground.
- 2v = sensor is indicating a warm condition for system being measured.
- 4v = sensor is indicating a cold condition for system being measured.
- 5v = sensor or wiring harness is open.

Remember a PTC type sensor will indicate opposite results on intermediate readings (i.e. 4 volts = warm).

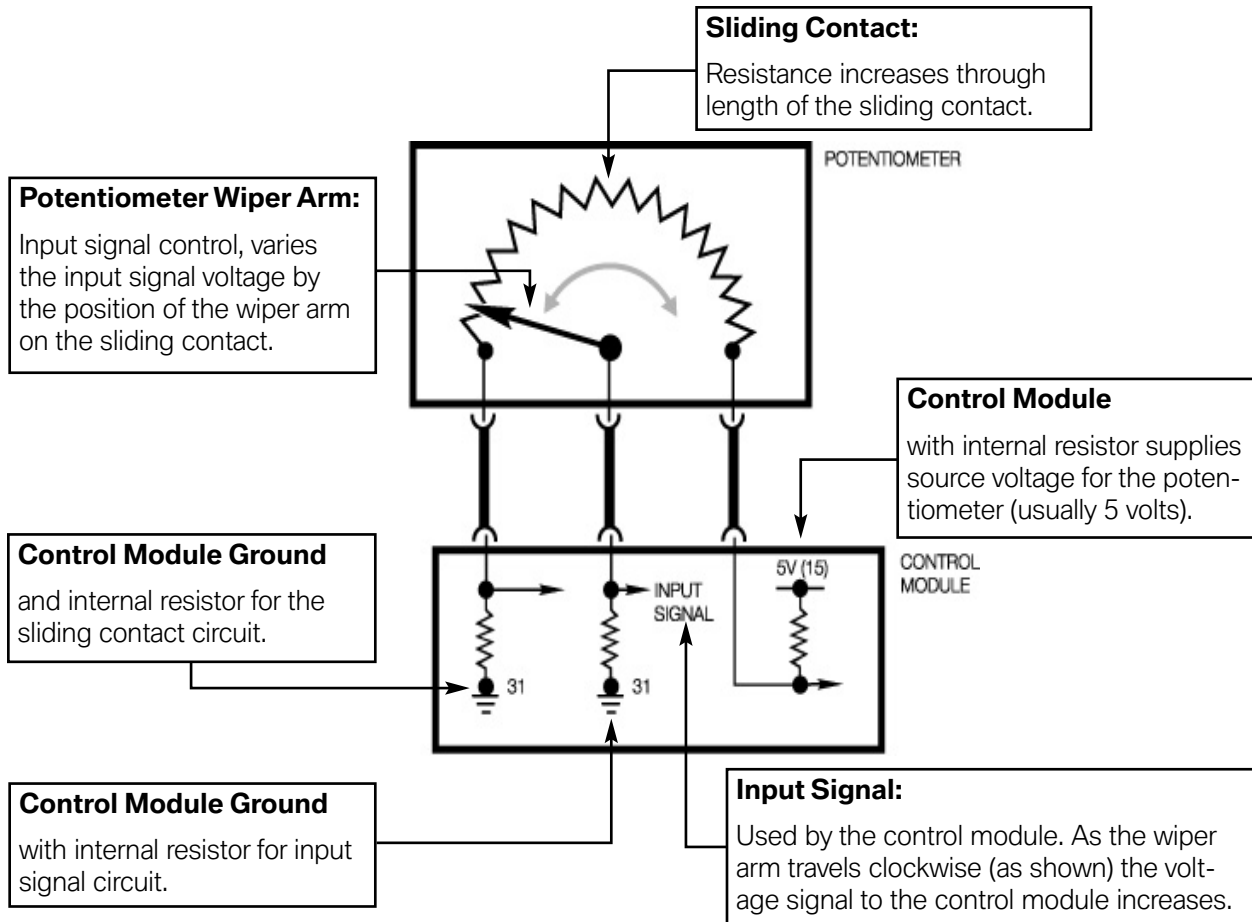
Typical Application of NTC Type sensor: <ul style="list-style-type: none">• Engine Coolant Temp Sensor• Transmission Temp Sensor• T-MAP Sensor• IHKA interior air temp sensor
--

Notes: _____

Potentiometers

A Potentiometer produces a gradually changing voltage signal to a control module. The signal is infinitely variable within the operating range of the sensor.

This varying voltage reflects a mechanical movement or position of the potentiometer wiper arm and its related components.



Typical Application of Potentiometers:

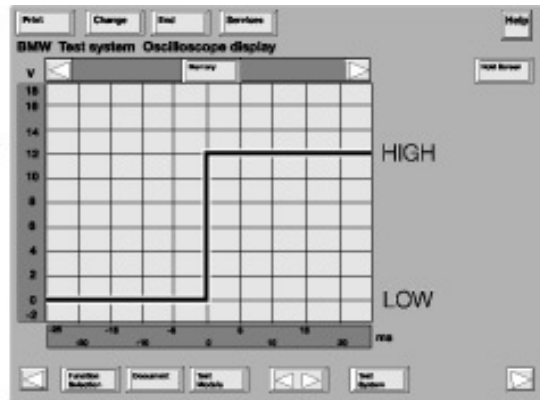
- Pedal Position Sensors
- Throttle Position Sensors (Also Feedback Potentiometers)

DC Digital Voltage Signals

Digital Signals transfer information through an electrical circuit by switching the current on or off. Unlike analog signals which vary voltage, a digital signal has only two possible states, control voltage or 0 voltage.

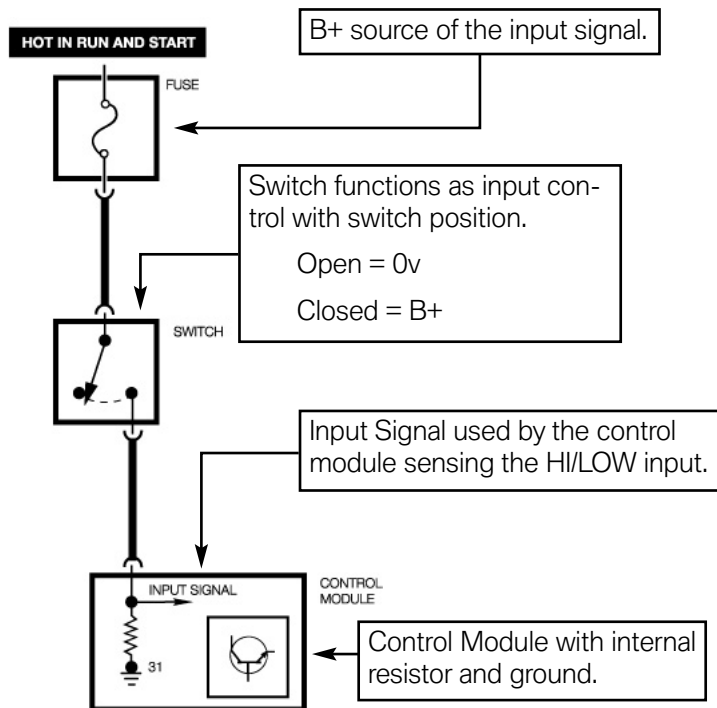
Two types of Digital Signals:

- Switched (High/Low) Signals
- Modulated Square Wave signals



Switched B+ (High/Low) Signal

This DC voltage signal produces an ON/OFF type input to the control module. The voltage level will indicate a specific operating condition.



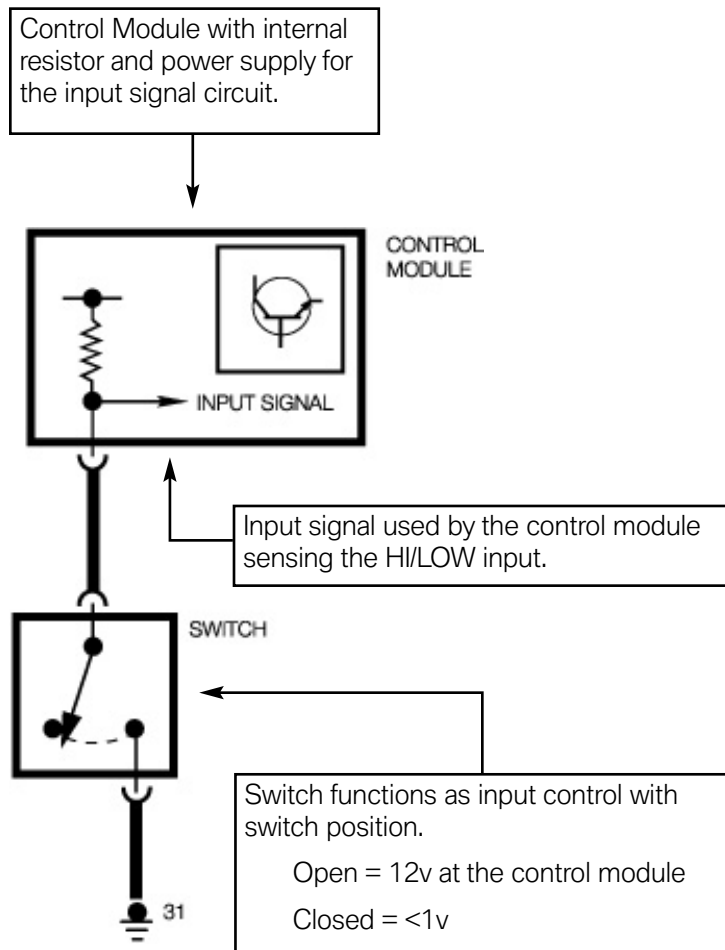
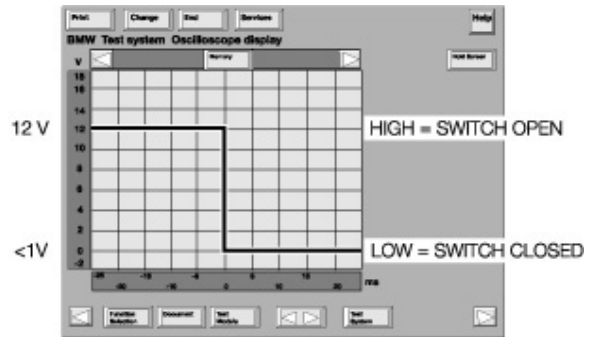
Typical Application of Switched B+

- Ignition Switch
- Light Switch
- Reed Switch
- Seat Belt Switch
- Hall Effect Switch (e.g. Brake Light Switch)

Switched B- (High/Low) Signal

This Ground Signal produces an ON/OFF type input to the control module. The voltage level will indicate a specific operating condition.

The only difference between a switched B- and a switched B+ is the voltage in which the signals are switched.



Typical Application of Switched B-

- Door Position Switch
- Window Switches
- Sunroof Switch

Modulated Square Wave

A Modulated Square Wave is a series of High/Low signals repeated rapidly.

Like the switched signals (B+, B-) the square wave has only two voltage levels.

A high level and a low level.

A modulated square wave has 3 characteristics that can be modified to vary the signal:

- Frequency
- Pulse Width
- Duty Cycle

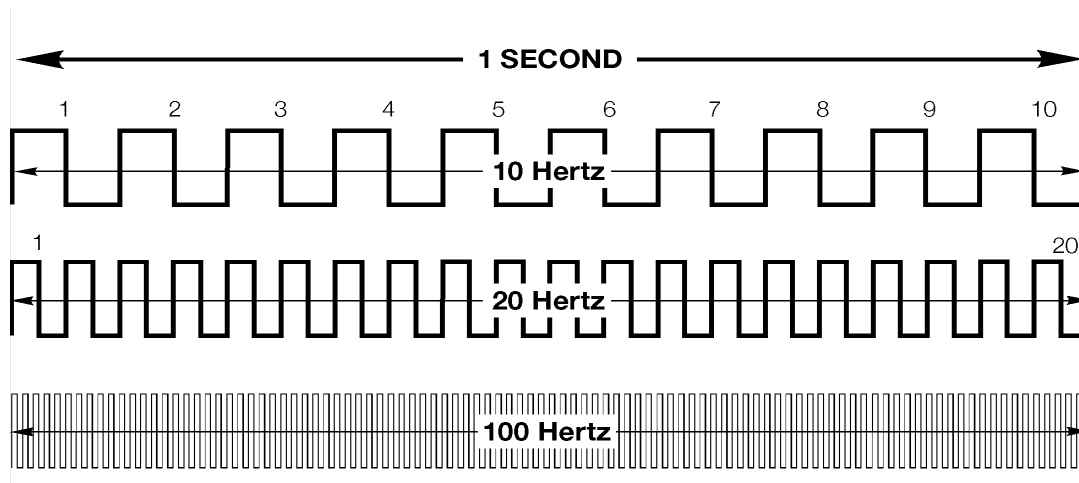
■ Frequency

The frequency of a modulated square wave signal is the number of complete cycles or pulses that occur in one second. This number of cycles or frequency is expressed in Hertz (Hz). 1Hz = 1 complete cycle per second.

An output function may use a fixed or varied frequency.



A Modulated Square Wave appears as a High/Low signal repeated rapidly over and over.



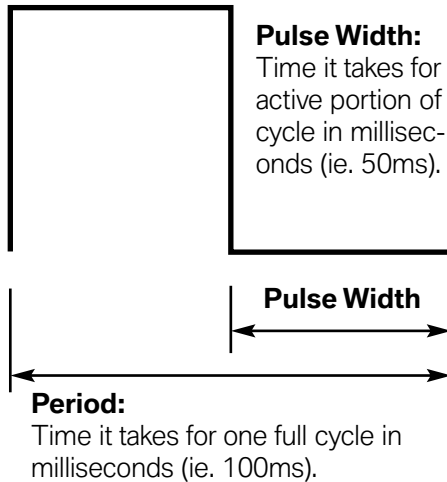
Typical Application of Fixed and Varied Frequency

Fixed Throttle command from EMS2000 to EDR

Varied Hall effect crank sensor
Hall effect wheel speed sensor
Hall effect camshaft sensor

■ Pulse Width

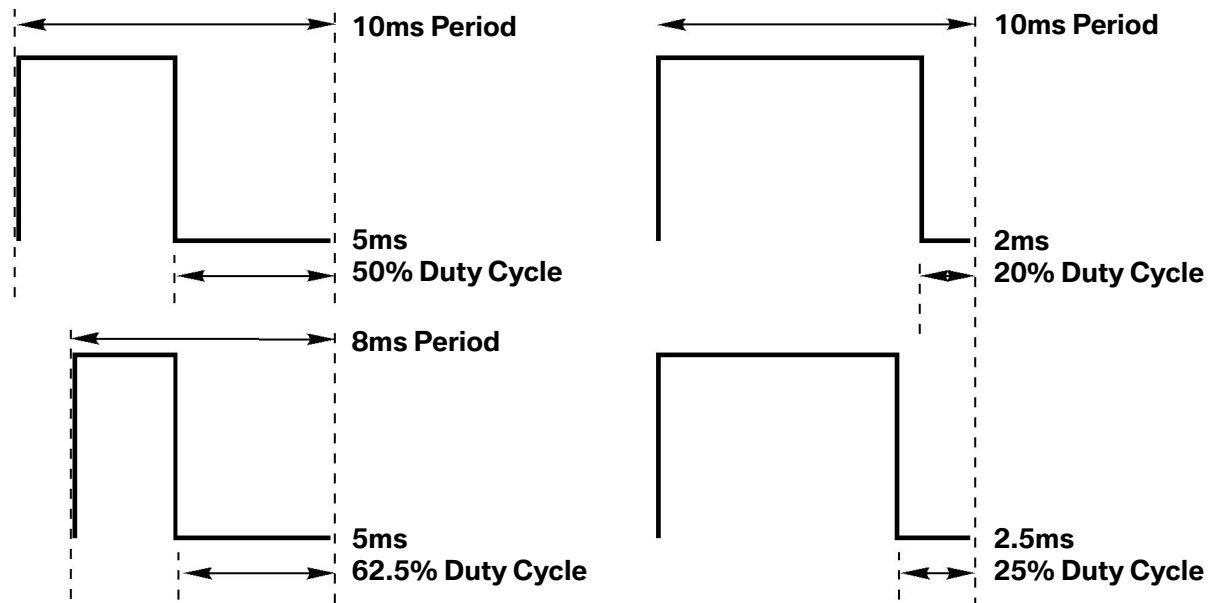
The Pulse Width of a signal is the length of time a pulse is on. Vehicle systems may use fixed or varied ON times/pulse width. Pulse width is expressed in milliseconds (ms).



■ Duty Cycle

The Duty Cycle of a square wave is the ratio of ON time to OFF time for one cycle. Duty cycle is expressed in %.

Vehicle systems use both fixed duty cycle signals and variable duty cycle signals.



Time

1 second = 1000 milliseconds (ms)
1/4 second = 250 milliseconds
1/100 second = 10 milliseconds

1/2 second = 500 milliseconds
1/10 second = 100 milliseconds
1/1000 second = 1 millisecond

DC Digital Sensors

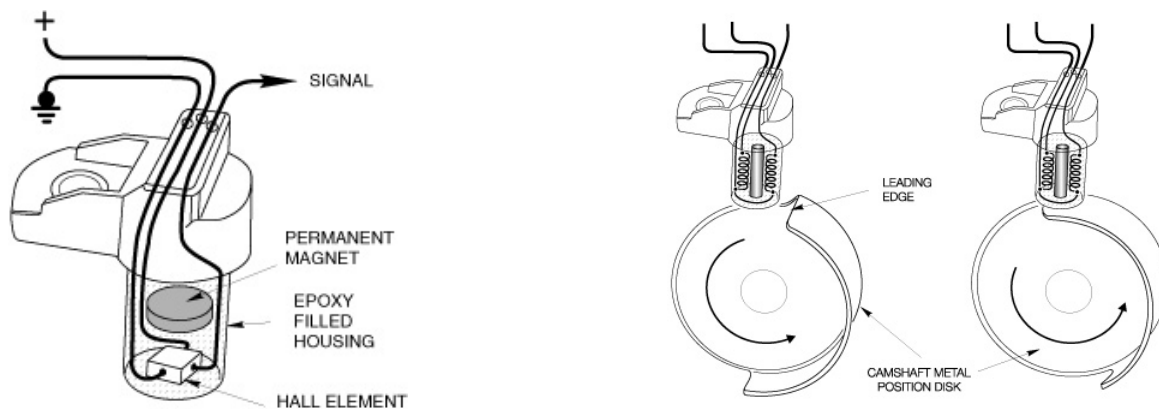
Hall Effect Sensors

Hall Effect Sensors can be used to produce ON/OFF signals or modulated square wave.

Hall Effect Sensors are electronic switches that react to magnetic fields to rapidly control the flow of current or voltage ON and OFF. It consists of an epoxy filled non-magnetic housing containing a hall element and a magnet, and a trigger wheel.

The Hall element is a thin non-magnetic plate which is electrically conductive. (Voltage will flow through the plate.) Electron flow is equal on both sides of the plate.

Since everything between the magnet and the hall element is non-magnetic the magnet (magnetic field) has no effect on the current flow.



As a metal disk or solid area of a toothed wheel, flywheel or other trigger device approaches the sensor, a magnetic field is created between the magnet and the disk. This magnetic field causes the electron flow to stop on one side of the plate. Electrons continue to flow on the other side of the plate.

The Hall Sensor Signal is a measurement of the voltage drop between the two sides of the plate or element. When the magnetic field increases (disc or solid toothed area in front of sensor) the voltage drop across the two sides of the element increases. High voltage on one side, low voltage on the other. The signal output from the sensor is High.

As the disc moves away from the sensor the magnetic field weakens and is lost. The loss of the magnetic field (blank toothed or open area of the wheel in front of the sensor) produces very little voltage drop across the two sides of the element. The output signal is Low.

A rapid switching of the voltage ON/OFF produces a HIGH/LOW signal that the control module uses to recognize speed and position.

Typical Application of Hall Effect sensors

- Crankshaft Sensors
- Camshaft Sensors
- Motor Position and Speed Sensors (e.g. Window Motor, Sunroof Motor)

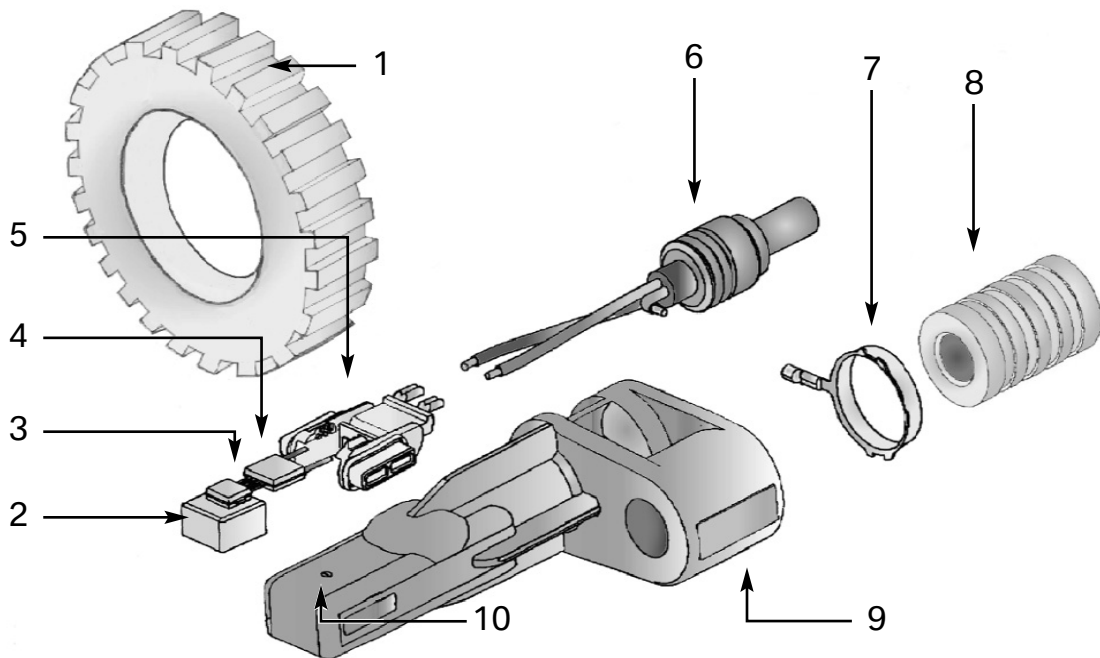
Magneto-resistive Sensors

The active sensing of the Magneto-resistive Sensor is particularly suitable for advanced stability control applications in which sensing at zero or near zero speed is required.

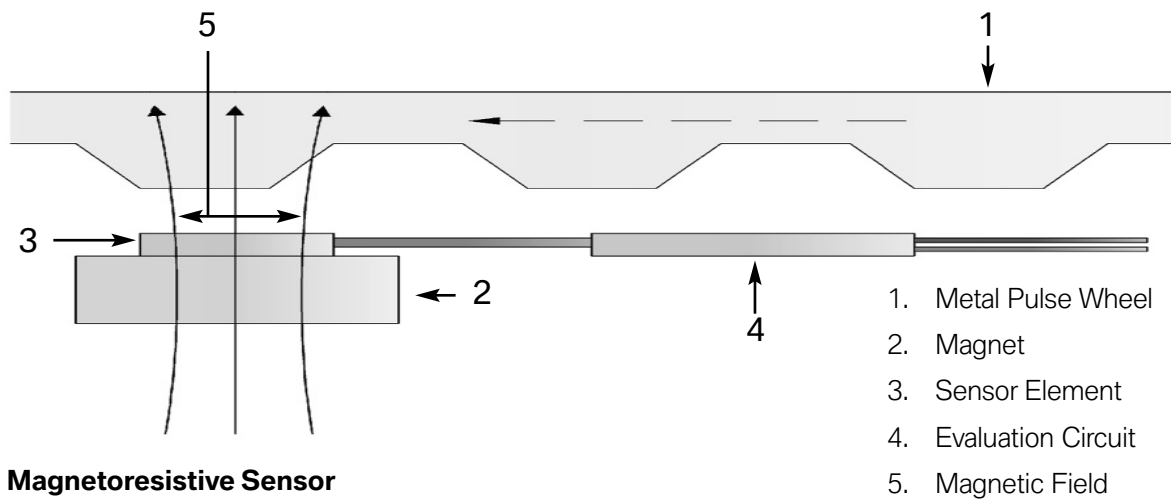
A permanent magnet in the sensor produces a magnetic field with the magnetic field stream at a right angle to the sensing element.

The sensor element is a ferromagnetic alloy that changes its resistance based on the influence of magnetic fields.

As the high portion of the pulse wheel approaches the sensing element a deflection of the magnetic field stream is created. This creates a resistance change in the thin film ferromagnetic layer of the sensor element.



- | | |
|-------------------------------|------------------------------------|
| 1. Metal Pulse Wheel | 6. Sensor Wiring With Weather Boot |
| 2. Magnet | 7. Ground Contact Ring |
| 3. Sensor Element | 8. Fastening Element |
| 4. Evaluation Module | 9. Sensor Housing |
| 5. Support for Sensor Element | 10. Pick-Up Surface |

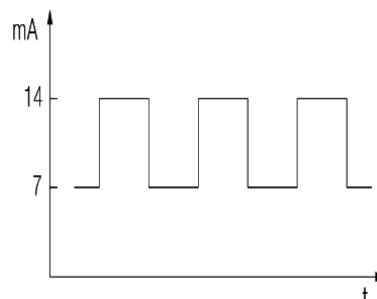


Magneto-resistive Sensor

The sensor element is affected by the direction of the magnetic field, not the field strength. The field strength is not important as long as it is above a certain level. This allows the sensor to tolerate variations in the field strength caused by age, temperature, or mechanical tolerances.

The resistance change in the sensor element affects the voltage that is supplied by the evaluation circuit. The small amount of voltage provided to the sensor element is monitored and the voltage changes (1 to 100mv) are converted into current pulses by the evaluation module.

- Signal Low-7mA
- Signal High-14mA



The sensor is supplied 12V by the control unit. Output voltage from the sensor is approximately 10V. The control unit counts the high and low current pulses to determine the wheel speed.

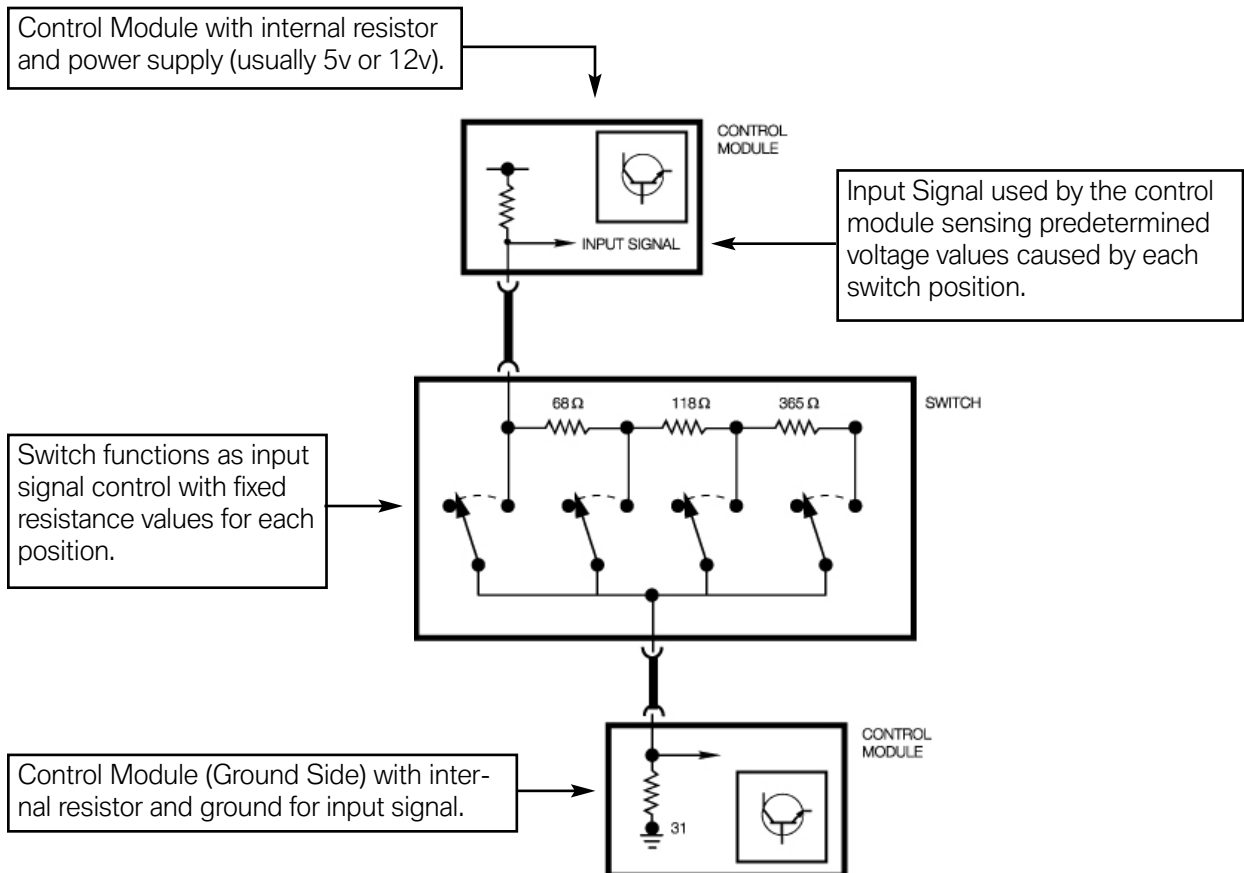
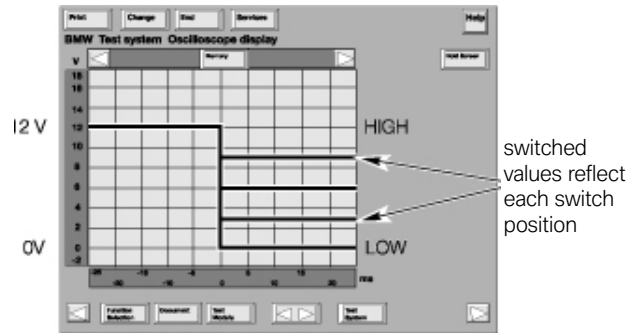
Typical Application of Magneto-resistive Sensor

- Currently used for wheel speed sensors.

Designated Value Signals

Designated values are produced through fixed resistance positions of a multi-position switch. As the switch is operated the voltage drop across the resistor(s) of each switch position causes the voltage level of the input signal to change to a predetermined voltage value.

These predetermined (designated) voltages signal the control module to perform specific functions.

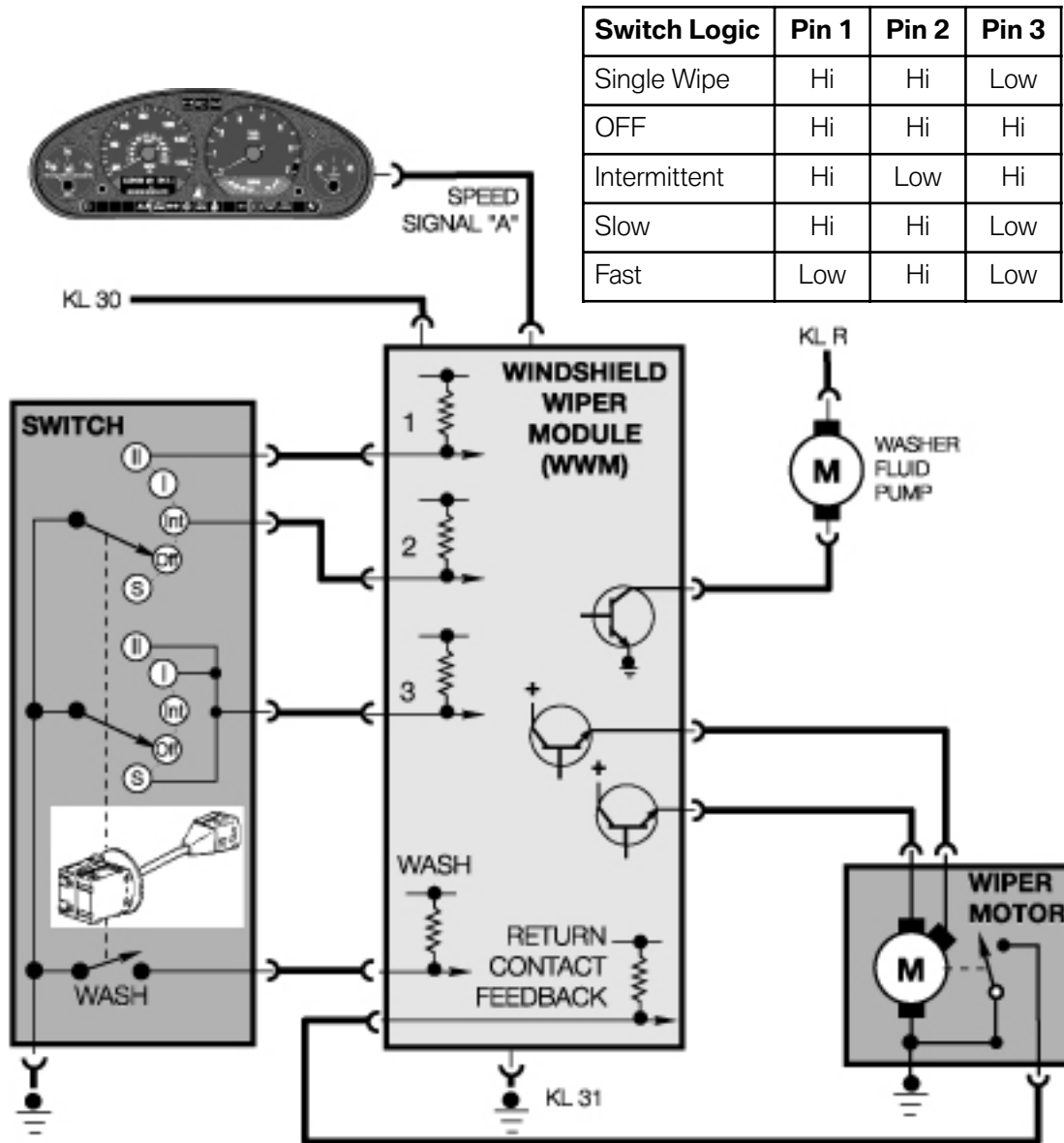


Coded Ground Signals

Coded ground signals produce a set of High/Low requests, the combination (pattern) of which is interpreted by the control module to perform a specific function.

Coded ground signals are generated through a switch or series of switches signaling the control module requests for operation.

Wiper Switch Schematic



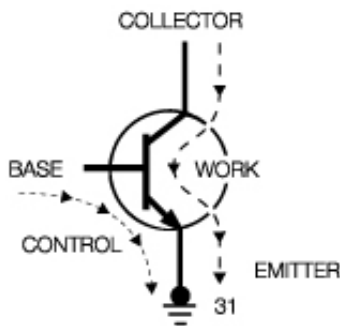
Typical Applications of Coded Ground Signals

- Wiper Switch
- Window Switch

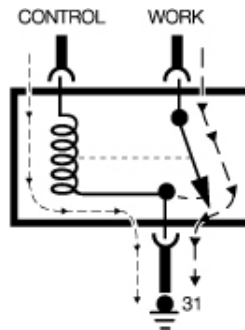
DC Digital Input/Output Stages

Transistor Final Stage Function

The transistor takes on a number of applications that must be understood to effectively analyze a circuit. The transistor in operation functions as two parts much like a relay. Both the relay and the transistor control high currents with a low current signal.



Transistor



Relay

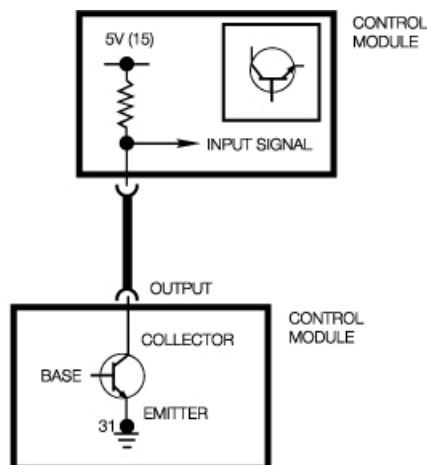
The transistor consists of three major sections:

- Base
- Emitter
- Collector

The base/emitter path functions as the control circuit activated by the control module to oversee or control the work.

The collector/emitter path functions as the work side of the circuit, supplying power or switching on the work.

In operation the transistor can either be switched ON momentarily, or supply a constant power or ground. The transistor can also be modulated or pulsed to supply a modulated square wave signal.

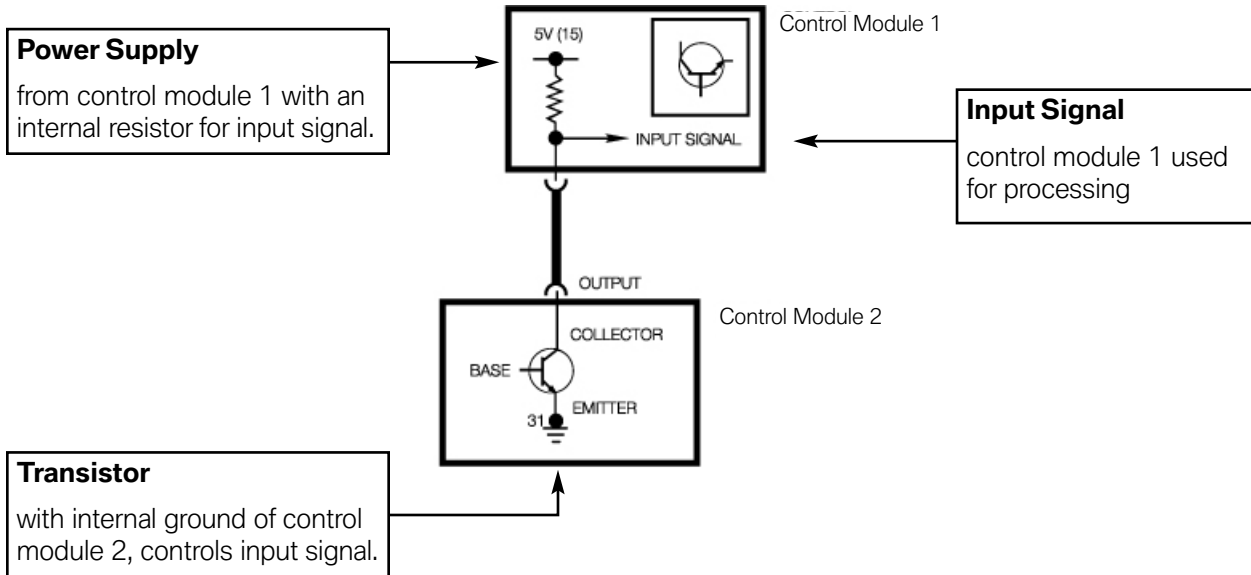


■ Modulated, Momentary, Constant B- as Input/Output

The input signal of control module 1 is an output signal of control module 2.

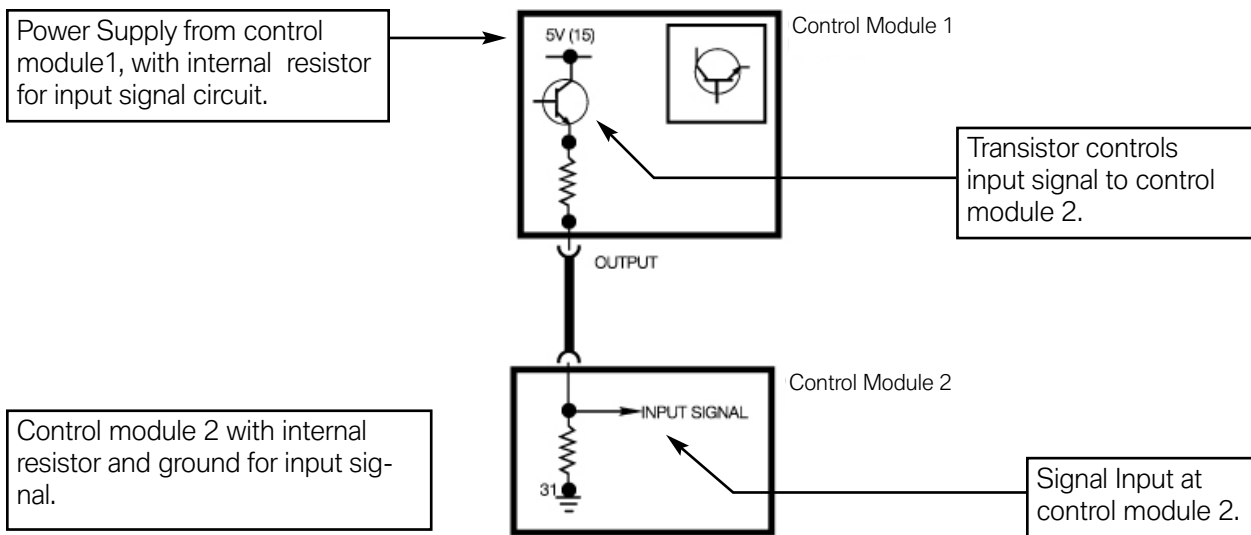
Control module 2 through activation of its internal transistor provides a ground input for control module 1.

The input signal at control module 1 is either a momentary/constant signal (i.e torque convertor signal from TCM to DME) or a modulated signal (i.e. vehicle speed signal ASC to DME).



■ Momentary/Constant B+ as an Input/Output Signal

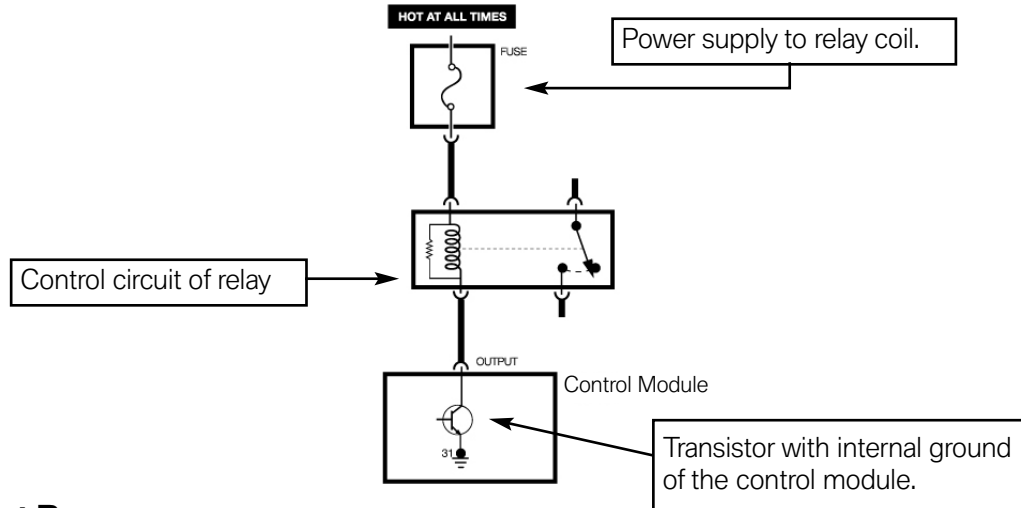
The input of control module 2 is controlled by control module 1 through internal activation of the transistor. Control module 1 provides power for the input circuit of control module 2.



■ Constant B-/B+ To Energize a Component Constant B-

Output function to energize a component.

Relay is energized by activation of the transistor inside the module. The transistor provides a ground for the relay coil, control module.



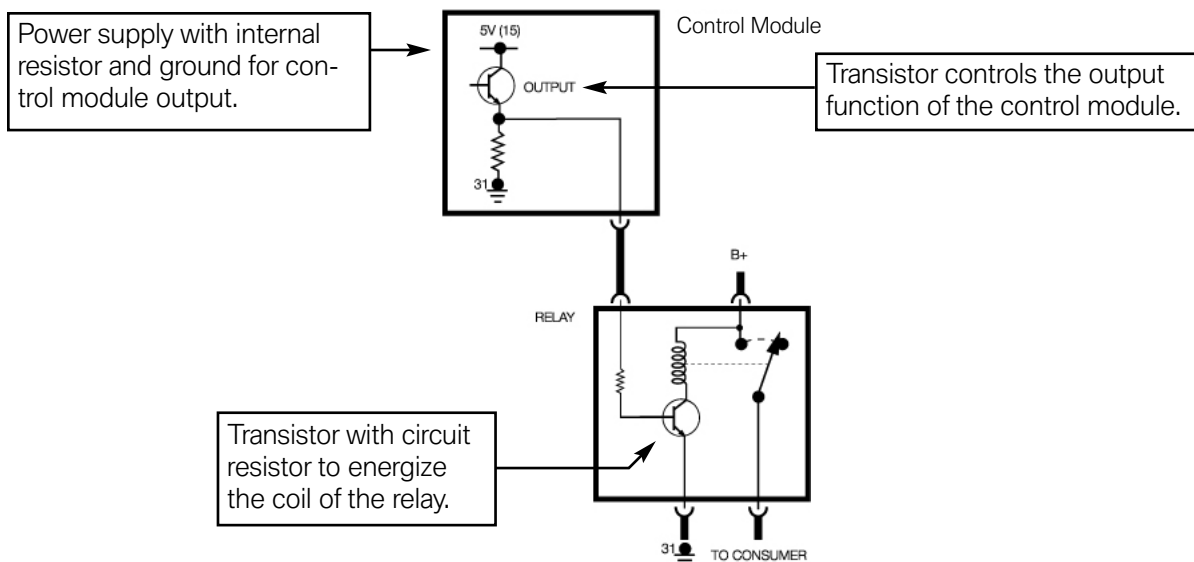
Constant B+

Control module output function to energize a component.

Transistor controls output function of the control module.

Control module supplies power to the relay.

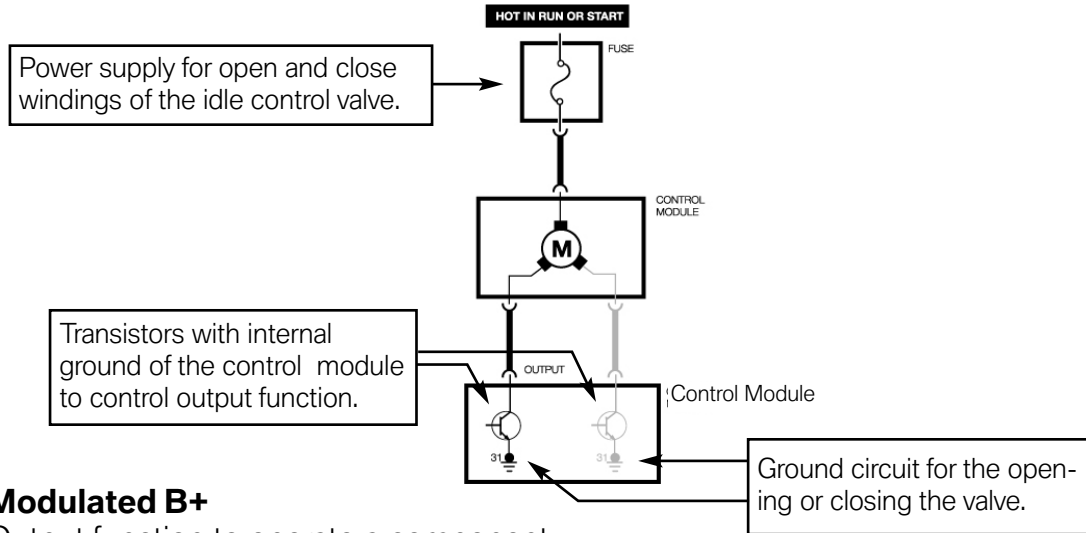
The relay is activated by the control module through activation of the transistor which provides a ground for the relay coil.



■ Modulated B-/B+ To Operate A Component
Modulated B-

Output function to operate a component.

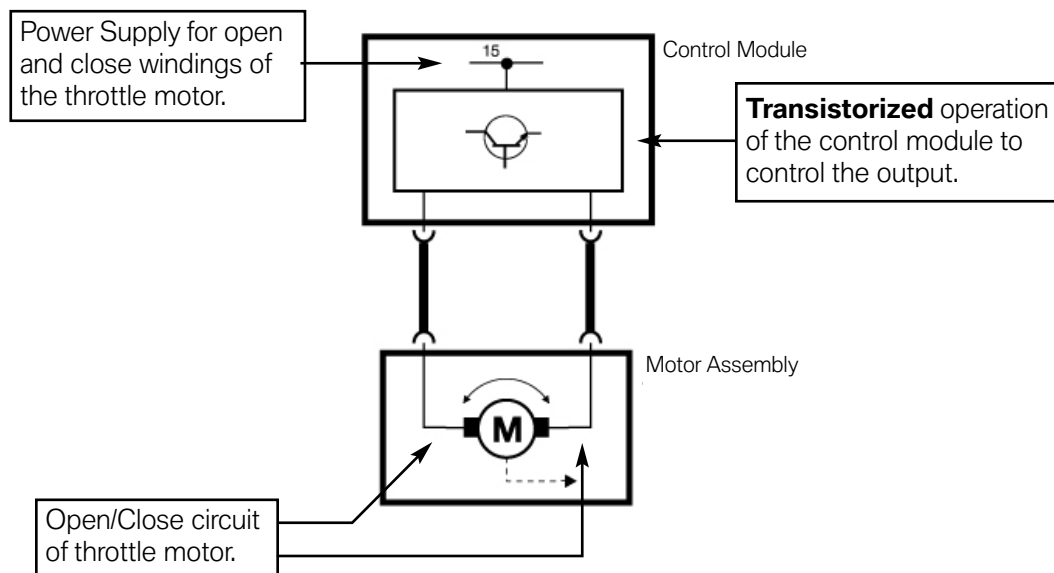
The idle valve motor is operated by the control module through activation of the transistor which provides a ground for the open winding of the valve.



Modulated B+

Output function to operate a component.

The motor is controlled by a transistorized function of the control module, which provides a modulated voltage at a specific frequency to the motor. The throttle position is changed by altering the Duty Cycle of the pulses.



Review Questions

1. *What are the two main groups of signals?* _____

2. *The two parts of an inductive sensor are:* _____

3. *The frequency of a signal indicates* _____

4. *In a NTC sensor as Temperature increases, Resistance* _____

5. *High resistance in a PTC sensor indicates hot or cold?* _____

6. *A 5V measurement in a NTC sensor means?* _____

7. *Describe the purpose of the three wires used on a potentiometer?* _____

8. *How many voltage level possibilities does a Modulated Square Wave contain?*

9. *The duty cycle of a square wave is the ratio of _____ to _____ time.*

10. *Duty cycle is expressed in* _____

11. *50 milliseconds is equal to _____ seconds.*
12. *When is the signal on a Hall Effect Sensor high?* _____

